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(54) Temperature sensing return electrode pad

(57) An electrosurgical return electrode is disclosed. The return electrode includes a conductive pad having one or more temperature monitoring zones and a patient-contacting surface configured to conduct electrosurgical energy and a temperature sensing circuit coupled to the conductive pad. The temperature sensing circuit includes at least one diode disposed within the at least one temperature monitoring zone, the at least one diode having a predetermined forward voltage drop that is indicative of temperature of at least one temperature monitoring zone.

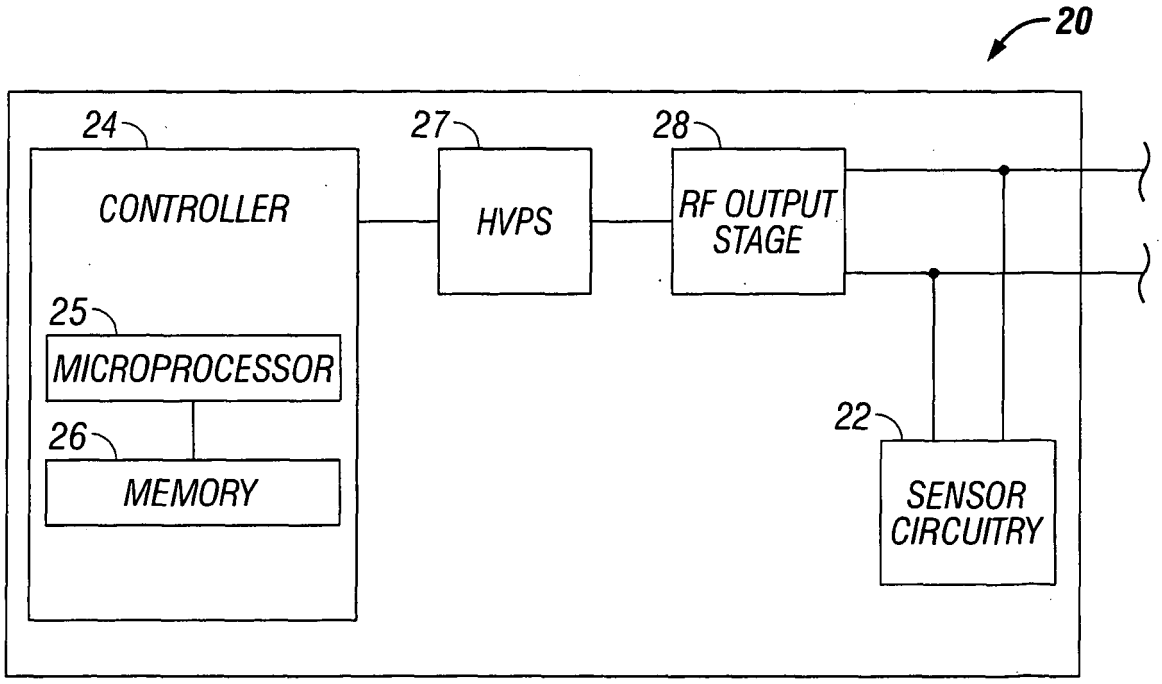

FIG. 2

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Description

BACKGROUND

Technical Field

[0001] The present disclosure relates to electrosurgical apparatuses, systems and methods. More particularly, the present disclosure is directed to monopolar electrosurgical systems utilizing one or more return electrode pads configured to sense temperature.

Background of Related Art

[0002] Energy-based tissue treatment is well known in the art. Various types of energy (e.g., electrical, ultrasonic, microwave, cryo, heat, laser, etc.) may be applied to tissue to achieve a desired surgical result. Electrosurgery typically involves application of high radio frequency electrical current to a surgical site to cut, ablate, coagulate or seal tissue. In monopolar electrosurgery, a source or active electrode delivers radio frequency energy from the electrosurgical generator to the tissue and a return electrode carries the current back to the generator. In monopolar electrosurgery, the source electrode is typically part of the surgical instrument held by the user and applied to the tissue to be treated. The patient return electrodes are typically in the form of pads adhesively adhered to the patient and are placed remotely from the active electrode to carry the current back to the generator.

[0003] The return electrodes usually have a large patient contact surface area to minimize heating at that site since the smaller the surface area, the greater the current density and the greater the intensity of the heat. That is, the area of the return electrode that is adhered to the patient is important because it is the current density of the electrical signal that heats the tissue. A larger surface contact area is desirable to reduce localized heat intensity. Return electrodes are typically sized based on assumptions of the maximum current utilized during a particular surgical procedure and the duty cycle (i.e., the percentage of time the generator is on).

[0004] The first types of return electrodes were in the form of large metal plates covered with conductive jelly. Later, adhesive electrodes were developed with a single metal foil covered with conductive jelly or conductive adhesive. However, one problem with these adhesive electrodes was that if a portion peeled from the patient, the contact area of the electrode with the patient decreased, thereby increasing the current density at the adhered portion and, in turn, increasing the heat applied to the tissue. This risked burning the patient in the area under the adhered portion of the return electrode if the tissue was heated beyond the point where circulation of blood could cool the skin.

[0005] To address this problem various return electrodes and hardware circuits, generically called Return Electrode Contact Quality Monitors (RECQMs), were developed. Such systems relied on measuring impedance at the return electrode to calculate a variety of tissue and/or electrode properties (e.g., degree of electrode adhesiveness, temperature). These systems were only configured to measure temperature as a function of the changes in impedance of the return electrode pads.

SUMMARY

[0006] The present disclosure relates to an electrosurgical return electrode that includes a conductive pad having a patient-contacting surface. The conductive pad includes a temperature circuit coupled to a power source and electrically insulated from the patient-contacting surface. The temperature circuit includes one or more diodes coupled in series with one or more resistors. The diodes are located within predetermined temperature measuring zone and provide for temperature measurement within corresponding temperature monitoring zones. In particular, the forward bias voltage across the diodes varies with the temperature. Thus, by monitoring the voltage, temperature can be monitored as a function thereof.

[0007] According to one aspect of the present disclosure, an electrosurgical return electrode is provided. The return electrode includes a conductive pad having one or more temperature monitoring zones and a patient-contacting surface configured to conduct electrosurgical energy and a temperature sensing circuit operatively associated with the conductive pad. The temperature sensing circuit includes at least one diode disposed within the at least one temperature monitoring zone, the at least one diode having a predetermined forward voltage drop which is indicative of temperature of at least one temperature monitoring zone.

[0008] A method for performing electrosurgery is also contemplated by the present disclosure. The method includes the steps of providing an electrosurgical return electrode including a conductive pad having one or more temperature monitoring zones and a patient-contacting surface configured to conduct electrosurgical energy and a temperature sensing circuit operatively associated with the conductive pad. The temperature sensing circuit includes at least one diode disposed within the at least one temperature monitoring zone, the at least one diode having a predetermined forward voltage drop which is indicative of temperature of at least one temperature monitoring zone. The method also includes the steps of placing the electrosurgical return electrode in contact with a patient, generating electrosurgical energy via an electrosurgical generator, supplying the electrosurgical energy to the patient via an active electrode, and monitoring the predetermined forward voltage drop to measure the temperature of the at least one temperature monitoring zone.

[0009] According to another aspect of the present disclosure an electrosurgical system for performing electrosurgery is disclosed. The electrosurgical system includes an electrosurgical generator configured to provide elec-

trosurgical energy and an electrosurgical return electrode. The return electrode includes a conductive pad having one or more temperature monitoring zones and a patient-contacting surface configured to conduct electrosurgical energy and a temperature sensing circuit operatively associated with the conductive pad. The temperature sensing circuit includes at least one diode disposed within the at least one temperature monitoring zone, the at least one diode having a predetermined forward voltage drop which is indicative of temperature of at least one temperature monitoring zone. The system also includes an active electrode to supply electrosurgical energy to a patient.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Various embodiments of the present disclosure are described herein with reference to the drawings wherein:

Fig. 1 is a schematic block diagram of an electrosurgical system according to the present disclosure;

Fig. 2 is a schematic block diagram of a generator according to one embodiment of the present disclosure;

Fig. 3 is a top view of the electrosurgical return electrode of the monopolar electrosurgical system of Fig. 1;

Fig. 4 is a cross-sectional side view of an electrosurgical return electrode having a positive temperature coefficient (PTC) material and adhesive material layers;

Figs. 5A-B illustrate one embodiment of an electrosurgical return electrode having temperature sensing circuit according to the present disclosure; and

Fig. 6 is a cross-sectional plan view of another embodiment of an electrosurgical return electrode having temperature sensing circuit according to the present disclosure.

DETAILED DESCRIPTION

[0011] Particular embodiments of the present disclosure are described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail.

[0012] Fig. 1 is a schematic illustration of an electrosurgical system according to one embodiment of the present disclosure. The system includes an electrosurgical instrument 2 having one or more electrodes for treating tissue of a patient P. The instrument 2 is a monopolar instrument including one or more active electrodes (e.g., electrosurgical cutting probe, ablation electrode(s), etc.). Electrosurgical RF energy is supplied to the instrument 2 by a generator 20 via an electrosurgical cable 4, which is connected to an active output terminal, allowing the instrument 2 to coagulate, seal, ablate and/or otherwise treat tissue. The energy is returned to the generator 20 through a return electrode 6 via a return cable 8. The system may include a plurality of return electrodes 6 that are arranged to minimize the chances of tissue damage by maximizing the overall contact area with the patient P. In addition, the generator 20 and the return electrode 6 may be configured for monitoring so-called "tissue-to-patient" contact to insure that sufficient contact exists therebetween to further minimize chances of tissue damage.

[0013] The generator 20 includes input controls (e.g., buttons, activators, switches, touch screen, etc.) for controlling the generator 20. In addition, the generator 20 may include one or more display screens for providing the user with variety of output information (e.g., intensity settings, treatment complete indicators, etc.). The controls allow the user to adjust power of the RF energy, waveform, and other parameters to achieve the desired waveform suitable for a particular task (e.g., coagulating, tissue sealing, intensity setting, etc.). The instrument 2 may also include a plurality of input controls that may be redundant with certain input controls of the generator 20. Placing the input controls at the instrument 2 allows for easier and faster modification of RF energy parameters during the surgical procedure without requiring interaction with the generator 20.

[0014] Fig. 2 shows a schematic block diagram of the generator 20 having a controller 24, a high voltage DC power supply 27 ("HVPS") and an RF output stage 28. The HVPS 27 provides high voltage DC power to an RF output stage 28, which then converts high voltage DC power into RF energy and delivers the RF energy to the active electrode. In particular, the RF output stage 28 generates sinusoidal waveforms of high RF energy. The RF output stage 28 is configured to generate a plurality of waveforms having various duty cycles, peak voltages, crest factors, and other suitable parameters. Certain types of waveforms are suitable for specific electrosurgical modes. For instance, the RF output stage 28 generates a 100% duty cycle sinusoidal waveform in cut mode, which is best suited for ablating, fusing and dissecting tissue, and a 1-25% duty cycle waveform in coagulation mode, which is best used for cauterizing tissue to stop bleeding.

[0015] The controller 24 includes a microprocessor 25 operably connected to a memory 26, which may be volatile type memory (e.g., RAM) and/or non-volatile type memory (e.g., flash media, disk media, etc.). The microprocessor 25 includes an output port that is operably connected to the HVPS 27 and/or RF output stage 28 allowing the microprocessor 25 to control the output of the generator 20 according to either open and/or closed con-

trol loop schemes. Those skilled in the art will appreciate that the microprocessor 25 may be substituted by any logic processor (e.g., control circuit) adapted to perform the calculations discussed herein.

[0016] A closed loop control scheme is a feedback control loop wherein sensor circuit 22, which may include a plurality of sensors measuring a variety of tissue and energy properties (e.g., tissue impedance, tissue temperature, output current and/or voltage, etc.), provides feedback to the controller 24. Such sensors are within the purview of those skilled in the art. The controller 24 then signals the HVPS 27 and/or RF output stage 28, which then adjust DC and/or RF power supply, respectively. The controller 24 also receives input signals from the input controls of the generator 20 or the instrument 2. The controller 24 utilizes the input signals to adjust power outputted by the generator 20 and/or performs other control functions thereon.

[0017] Figs. 3 and 4 illustrate various embodiments of the return electrode 6 for use in monopolar electrosurgery. The return electrode 6 includes a conductive pad 30 having a top surface and a patient-contacting surface 32 configured to receive current during monopolar electrosurgery. The patient-contacting surface 32 is made from a suitable conductive material such as metallic foil. While Fig. 3 depicts the return electrode 6 in a general rectangular shape, it is within the scope of the disclosure for the return electrode 6 to have any suitable regular or irregular shape.

[0018] Referring to Fig. 4, another embodiment of the return electrode 6 is shown, wherein the conductive pad 30 includes a positive temperature coefficient (PTC) material layer 38 deposited thereon. The PTC material 38 can be made of, inter alia, a polymer/carbon-based material, a cermet-based material, a polymer material, a ceramic material, a dielectric material, or any combinations thereof. The PTC material layer 38 acts to distribute the temperature created by the current over the surface of the electrosurgical return electrode 6, which minimizes the risk of a patient burn. The return electrode 6 further includes an adhesive material layer 39 on the patient-contacting surface 32. The adhesive material can be, but is not limited to, a polyhesive adhesive, a Z-axis adhesive, a water-insoluble, hydrophilic, pressure-sensitive adhesive, or any combinations thereof, such as POLYHESIVE™ adhesive manufactured by Valleylab of Boulder, Colorado. The adhesive material layer 39 ensures an optimal surface contact area between the electrosurgical return electrode 6 and the patient "P," which limits the possibility of a patient burn. In an embodiment where PTC material layer 38 is not utilized, the adhesive material layer 39 may be deposited directly onto the patient-contacting surface 32.

[0019] Figs. 5A and 5B shows the return electrode 6 including a temperature sensing circuit 40 disposed therein. The temperature sensing circuit 40 includes one or more temperature sensor arrays 41 and 43 having at least one temperature sensor. Contemplated temperature sensors include thermocouples, thermistors, semiconductor (e.g., silicon) diodes, ferrite materials and Hall effect devices. The temperature sensing circuit 40 is disposed on a flex circuit (e.g., a flexible holding substrate 48) manufactured from suitable substrate, such as a polyimide film. Examples are films sold under the trademarks MYLAR™ and KAPTON™ and the like.

[0020] The diodes 42 are connected in series with one or more current limiting resistors 44 and are utilized as temperature sensors. The resistor 44 is coupled in series with the diode 42, having a resistance selected to set and limit the current flowing through the diode 42 at a predetermined level. The current flow to the diodes 42 is provided by a power source 50, such as a low voltage DC power source (e.g., battery, AC/DC transformer, etc.) connected in series with the diodes 42 and resistors 44 via interconnection wires 46. The power source 50 may be integrated into the generator 20 and draw power from the same source as the HVPS 27 (e.g., AC outlet). In one embodiment, interconnection of the diodes 42 and the resistors 44 is achieved by deposition of metal traces on the holding substrate 48 and soldering of the diodes 42 and the resistors 44 directly into the holding substrate 48. The holding substrate 48 may also electrically insulate the temperature sensing circuit 40 from the patient-contacting surface 32 to prevent RF energy being returned to the generator 20 from interfering with the circuit components.

[0021] The diodes 42 are forward biased such that current flows initially through the resistor 44 and from the diode's anode to the diode's cathode. In a forward biased diode 42, forward voltage drop (Vf) is produced that is in the range of about 0.5V to about 5V depending on the type of diode (e.g., light emitting diode). The forward voltage is directly dependent on the temperature. In particular, as the temperature increases, the semiconductor material within the diode 42 undergoes changes in their valence and conduction bands and consequently Vf decreases. Thus, by keeping the current flowing through the diode 42 constant via the resistor 44 and measuring the forward bias voltage allows for determination of the temperature of the diode 42.

[0022] The Vf signal is transmitted through the interconnection wires 46 to the generator 20, wherein the sensor circuit 22 analyzes the Vf to determine a corresponding temperature value. As those skilled in the art will appreciate, each of the interconnection wires 46 may include a corresponding isolation circuit (e.g., optical couplers) to translate electric signals (e.g., Vf) across isolation barriers, thereby isolating the temperature sensing circuit 40 from the RF supply.

[0023] The analysis process may include passing the Vf signals through an analog-to-digital converter and then multiplying the digitized Vf signal by a predetermined factor to arrive at a corresponding temperature value. The factor is derived empirically taking into consideration electrical properties of the diode 42, resistor 44 as well as electrical properties of the current being passed there-

through. The temperature signal is then transmitted to the controller 24 where it is further analyzed to determine appropriate action. For instance, comparing temperature measurements with a predetermined temperature threshold and adjusting or terminating the RF energy supply if the temperature measurement is larger than the predetermined threshold.

[0024] Temperature across the patient-contacting surface 32 may vary due to a number of factors (e.g., moisture content, adherence, etc.) affecting current density. Therefore, it may be desirable to measure temperatures at various points in the conductive pad 30. Measuring temperature at various points allows for pinpointing the location of so-called "hot spots," segments of the patient-contacting surface 32 where current density exceeds that of the surrounding area and results in pad burn. Since measurement of Vf for each diode 42 provides for determination of corresponding temperature at the location of the diode 42, placing the diodes 42 strategically within the conductive pad 30 allows for monitoring of temperature at those locations.

[0025] With reference to Fig. 5A, each resistor 44 and diode 42 pair is disposed within the conducting pad 30 such that the diode 42 provides temperature readings for a corresponding temperature monitoring zone 45. The size of the monitoring zone 45 depends on the distance between the diodes 42. The conductive pad 30 may include any number of monitoring zones 45 of varying sizes. Each diode 42 is identified by the sensor circuit 22 as being associated with a particular monitoring zone 45 such that, when Vf signals are transmitted and subsequently converted into temperature readings, the generator 20 provides temperature monitoring for each of the monitoring zones 45. This data is utilized to instruct the user which specific portion of the conductive pad 30 includes a hot spot so that preventative action may be taken, if necessary. This may include automatic RF supply termination and/or adjustment or manual termination of RF supply to ensure that the conductive pad 30 adheres properly to the patient at the identified hot spot.

[0026] As shown in Fig. 6, the temperature sensor arrays 41 and 43 include a single resistor 44 connected in series with a plurality of diodes 42 disposed within a respective temperature monitoring zone 45. Since the diodes 42 are connected in series to one resistor 44, the current supplied to the diodes 42 is the same. Consequently, measuring the Vf across the diodes 42 provides the temperature for the entire respective temperature monitoring zone 45. This circuit arrangement provides an average temperature measurement over larger segments of the conductive pad 30 (e.g., entire area). Those skilled in the art will appreciate that various configurations of the resistor 44 and diode 42 are contemplated to ensure that temperature of various segments of the conductive pads 30 are monitored.

[0027] While several embodiments of the disclosure have been shown in the drawings and/or discussed herein, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of particular embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

Claims

1. An electrosurgical return electrode, comprising:

a conductive pad including at least one temperature monitoring zone and a patient-contacting surface configured to conduct electrosurgical energy; and

a temperature sensing circuit coupled to the conductive pad, the temperature sensing circuit including at least one diode disposed within the at least one temperature monitoring zone, the at least one diode having a predetermined forward voltage drop that is indicative of temperature of the at least one temperature monitoring zone.

2. An electrosurgical return electrode according to claim 1, wherein the at least one diode is forward biased.

3. An electrosurgical return electrode according to any preceding claim, further comprising a holding substrate for housing the temperature sensing circuit, the holding substrate being configured to electrically insulate the temperature sensing circuit from the patient-contacting surface.

4. An electrosurgical return electrode according to any preceding claim, wherein the temperature sensing circuit includes at least one resistor coupled in series with the at least one diode.

5. An electrosurgical return electrode according to any preceding claim, wherein the temperature sensing circuit is coupled to at least one power source configured to supply current to the at least one diode.

6. An electrosurgical return electrode according to claim 4, wherein the at least one resistor is configured to limit the current flowing through the at least one diode to a predetermined level.

7. The electrosurgical return electrode according to any preceding claim, wherein the conductive pad includes an adhesive material disposed on the patient-contacting surface.

8. The electrosurgical return electrode according to any

preceding claim, wherein the conductive pad is at least partially coated with a positive temperature coefficient (PTC) material.

9. An electrosurgical system for performing electrosurgery, the electrosurgical system comprising:

an electrosurgical generator configured to provide electrosurgical energy;
an electrosurgical return electrode including a conductive pad including at least one temperature monitoring zone and a patient-contacting surface configured to conduct electrosurgical energy, and a temperature sensing circuit operatively associated with the conductive pad, the temperature sensing circuit including at least one diode disposed within the at least one temperature monitoring zone and at least one resistor coupled in series with the at least one diode, the at least one diode having a predetermined forward voltage drop that is indicative of temperature of the at least one temperature monitoring zone; and
an active electrode to supply electrosurgical energy to a patient.

10. An electrosurgical system according to claim 9, wherein the at least one diode is forward biased.

11. An electrosurgical system according to any of claims 9 and 10, further comprising a holding substrate for housing the temperature sensing circuit, the holding substrate being configured to electrically insulate the temperature sensing circuit from the patient-contacting surface.

12. An electrosurgical system according to any of claims 9, 10 and 11, wherein the temperature sensing circuit is coupled to at least one power source configured to supply current to the at least one diode.

13. An electrosurgical system according to any of claims 9, 10, 11 and 12, wherein the temperature sensing circuit includes at least one resistor coupled in series with the at least one diode.

14. An electrosurgical system according to claim 13, wherein the at least one resistor is configured to limit the current flowing through the at least one diode to a predetermined level.

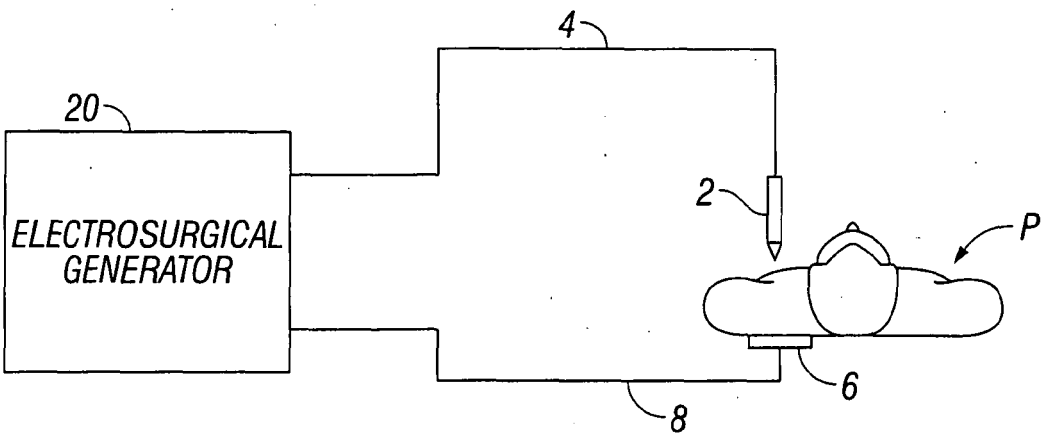
4
20
ELECTROSURGICAL GENERATOR
2
P
6
8

FIG. 1

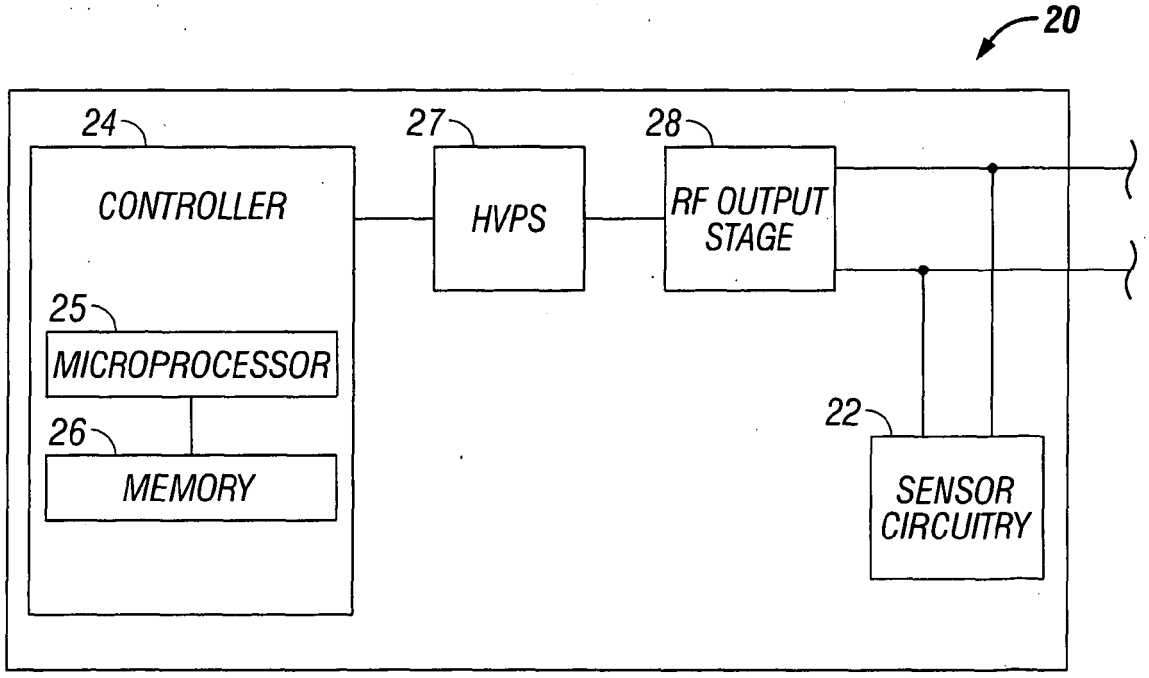
20
24
CONTROLLER
25
MICROPROCESSOR
26
MEMORY
27
HVPS
28
RF OUTPUT STAGE
22
SENSOR CIRCUITRY

FIG. 2

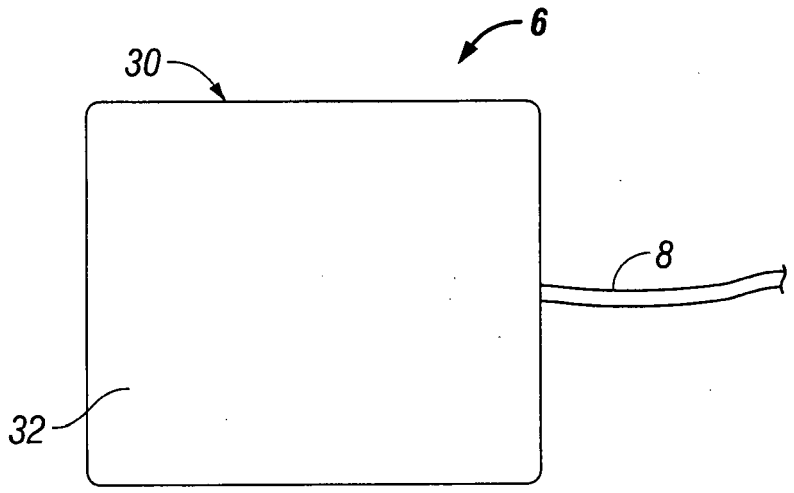

FIG. 3

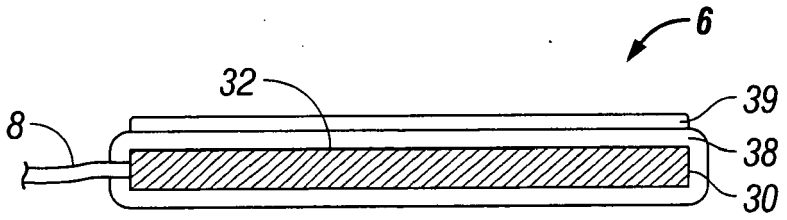

FIG. 4

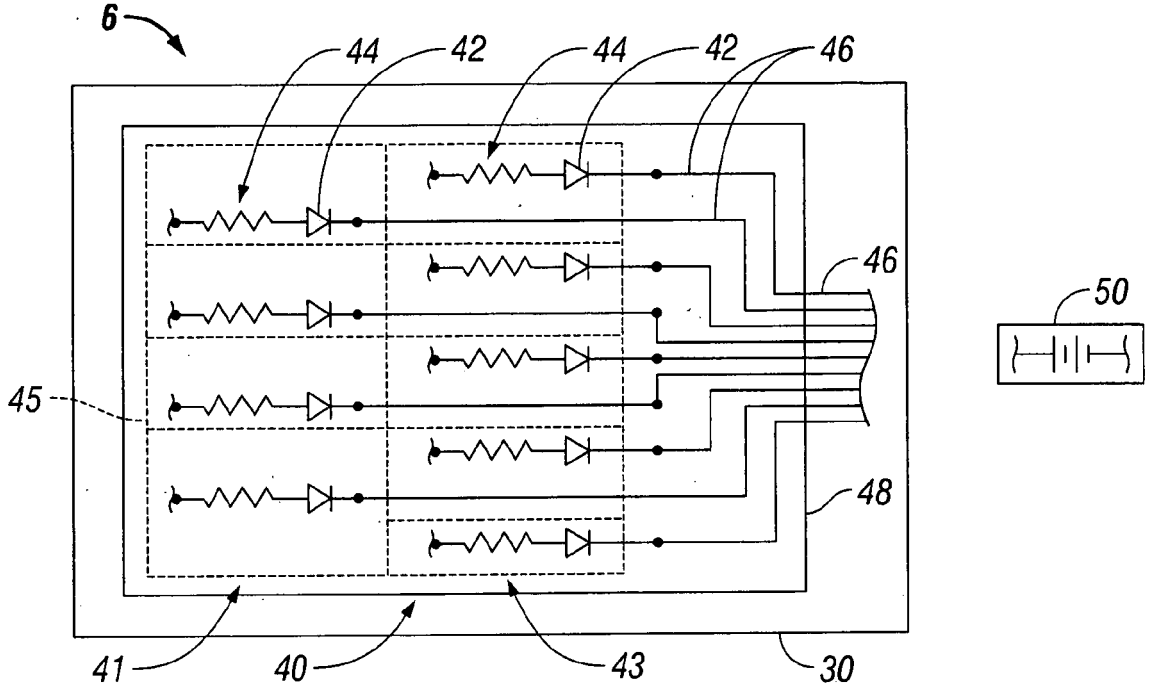

FIG. 5A

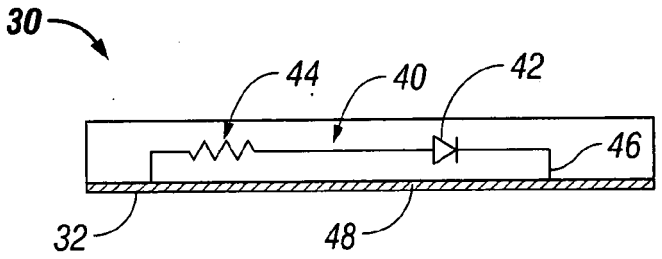

FIG. 5B

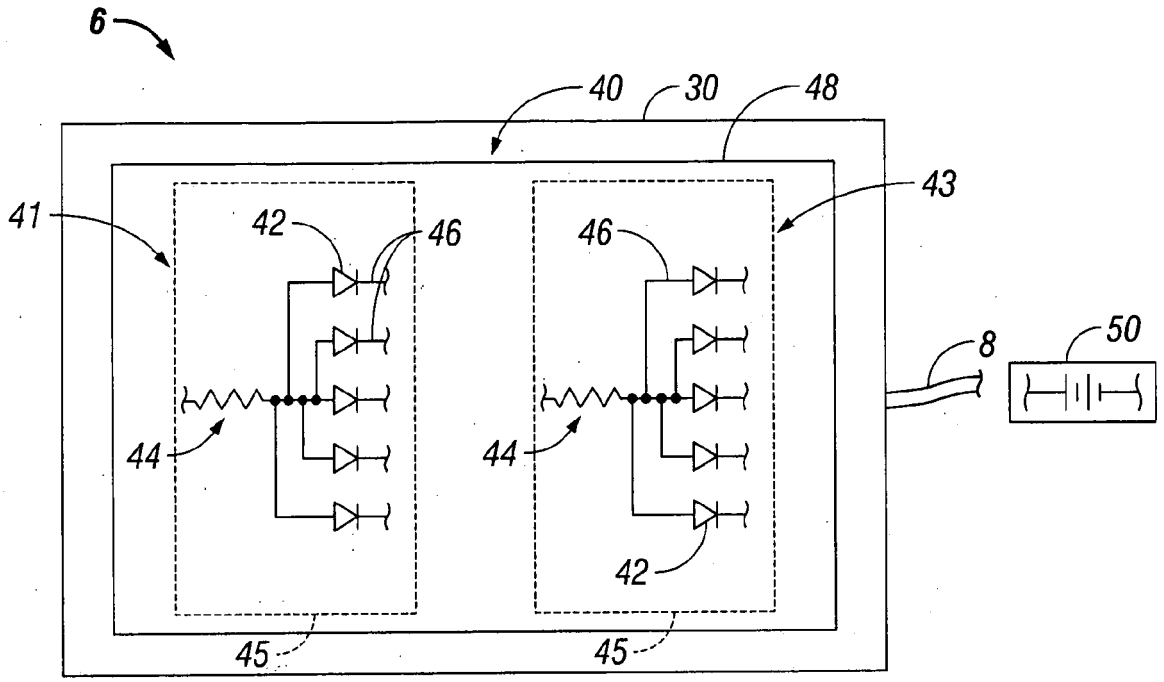

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 01 9173

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 January 2008	MOLINA SILVESTRE, A

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 01 9173

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